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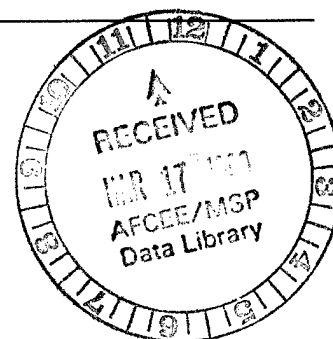
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PARSONS ENGINEERING SCIENCE, INC.

A UNIT OF PARSONS INFRASTRUCTURE & TECHNOLOGY GROUP

5390 Triangle Parkway, Suite 100 • Norcross, Georgia 30092 • (770) 446-4900 • Fax: (770) 446-4910

March 16, 1999



Major Ed Marchand
AFCEE/ERT
3207 North Road, Building 532
Brooks AFB, Texas 78235-5363

Subject: Letter of Transmittal
Results of Bioventing System Monitoring at Eglin Main Base Old Fire
Training Area (Site FT-28), Eglin Air Force Base, Florida
(Contract No. F41624-92-D-8036, Order 17)

Dear Major Marchand:

Please find enclosed three copies of Results of Bioventing System Monitoring letter report for the Eglin Main Base Old Fire Training Area Site prepared by Parsons Engineering Science, Inc. (Parsons ES) for the Air Force Center for Environmental Excellence (AFCEE) and Eglin Air Force Base (AFB), Florida. Three copies of this document have also been delivered to Mr. Ralph Armstrong at Eglin AFB.

If you have any questions concerning the enclosed letter report, please call myself at (678) 969-2361 or Mr. John Ratz at (303) 831-8100.

Sincerely,

PARSONS ENGINEERING SCIENCE, INC.

Steve Ratzlaff, P.E.
Site Manager

Enclosures

c: Mr. Ralph Armstrong, Eglin AFB (3 copies)
File 726876.43210.E



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March 16, 1999

Major Ed Marchand
AFCEE/ERT
3207 North Road, Bldg 532
Brooks AFB, Texas 78235-5363

Subject: Results of Bioventing System Monitoring at Eglin Main Base Old Fire
Training Area (Site FT-28), Eglin Air Force Base, Florida
(Contract No. F41624-92-D-8036, Order 17)

Dear Major Marchand:

This letter presents the results of the bioventing system monitoring performed by Parsons Engineering Science, Inc. (Parsons ES) during the week of 8 February 1999 at the Eglin Main Base Old Fire Training Area (old Eglin FTA) at Eglin Air Force Base (AFB), Florida. This site is also identified as Installation Restoration Program (IRP) Site FT-28. Soil gas samples were collected and *in situ* respiration testing was performed by Parsons ES to assess the extent of remediation completed during approximately 1 year of expanded-scale bioventing system operation. The purpose of this letter is to summarize site and bioventing activities to date, present the results of the most recent respiration testing and soil gas sampling event, and make recommendations based on site data. A site layout and three tables are attached. Attachment A contains tables and graphs that were employed for calculations.

SITE/PROJECT HISTORY

The old Eglin FTA site was used for the training of personnel in the suppression of fires associated with aircraft accidents. The site was active from the 1950s to the late 1970s or early 1980s. During the 1950s and 1960s, a variety of flammable liquids including waste fuel, waste oil, and contaminated fuel were used for fires. Training exercises were conducted as frequently as two to three fires per week. Due to pollution concerns in early 1970s, training exercises became less frequent and the quantities and types of fuels used were reduced.

The common practice used during training exercises involved transferring flammable liquids to the burn pit via tanker truck or buried pipe from the onsite AST. The flammable liquid was then sprayed onto a representative mock plane located in the center of the burn pit. Since the burn pit was equipped with an earthen berm, much of the fuel remained confined and was easily ignited. Any residual fuel that remained after a typical training exercise, flowed through a buried drain pipe to a small unlined depression east of the training area and was allowed to seep into the soil or evaporate.



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IRP Phase I and Phase II Investigation

The IRP Phase I investigation was conducted by Engineering Science, Inc. (ES, now known as Parsons ES) in 1981 to identify the potential for environmental contamination from past waste use and disposal at inactive and active facilities at Eglin AFB. The old Eglin FTA was identified as a potential source for environmental contamination in the investigation. However, the site was not ranked as a high priority for further evaluation (ES, 1981).

Even though the site was not ranked as a high priority in the Phase I investigation, the site was included in the IRP Phase II, Stage 2 investigation at the request of the Air Force Systems Command (ES, 1988). The investigation included drilling six soil borings (EAFB1-1 through EAFB1-6), converting three of the borings to monitoring wells (EAFB1-1 through EAFB1-3) and collecting groundwater samples from the wells.

The IRP Phase II, Stage 3 field effort began in March 1988 and was designed to obtain additional data to further characterize the site (ES, 1992). A soil gas survey was conducted to aid in soil boring and well siting. This information was used to advance nine soil borings (1SB1 through 1SB9) to the soil-water interface and install six monitoring wells (1MW1, 1MW2, 1MW3, 1MW4, 1MW5, and 1MW6). Monitoring wells 1MW1 and 1MW3 were installed as four-inch diameter deep wells.

Pilot-Scale Bioventing System Installation and Testing

In March 1994, a pilot-scale bioventing system was installed at the site, and a bioventing pilot test was performed according to AFCEE protocol procedures (Hinchee *et al.*, 1992) to evaluate the effectiveness of this technology to reduce hydrocarbon concentrations in the vadose zone soils. An air injection vent well (VW) was installed (VW-1), along with three soil vapor monitoring points (MPA, MPB, and MPC). During installation of the pilot-scale bioventing system, significant evidence of soil contamination (strong petroleum odor, staining, and elevated photoionization detector [PID] and total hydrocarbon readings) was observed at the boreholes for the VW and MPs. The pilot-scale system ran from July 1994 to July 1995 (ES, 1993 and 1994).

RCRA Facility Investigation

A Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) was performed by O'Brien and Gere, Inc. in 1995. The RFI field effort began in March 1994 and was designed to define the extent of site contamination (O'Brien & Gere, Inc., 1995). A second soil gas survey was conducted, surface and subsurface soil samples were collected, and six additional monitoring wells were installed. An additional soil boring (SB17) was advanced in April 1996 on the west side of the burn pit within an area of observed black-stained soil. Ten hand auger borings were also completed to depths of up to 5 feet below ground surface (bgs) in May 1996 to determine the extent of the black stained soils surrounding the primary burn pit (O'Brien and Gere, Inc., 1996a).

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RCRA Corrective Measures Study

The RFI and subsequent risk assessment concluded that hypothetical future risks to adult and child residents are primarily associated with ingestion of contaminated groundwater, inhalation of volatile organic compounds (VOCs) in groundwater through showering, and dermal contact with groundwater through showering (O'Brien & Gere, Inc., 1995). The RFI indicated contaminants currently present in surface and subsurface soil are a continued source of groundwater contamination.

A RCRA Corrective Measures Study (CMS) was performed by O'Brien and Gere, Inc., in 1996 (O'Brien & Gere, Inc., 1996b). The CMS was based on the results of previous investigations and the 1995 RFI. The selected remediation alternative included modification of the existing bioventing system to continue *in situ* treatment of soil near the burn pit and extension to the AST area.

Expanded-Scale Bioventing System Installation and Operation

Based on positive results from the 1-year bioventing pilot test conducted from July 1994 to July 1995, an expanded-scale bioventing system for treatment of vadose zone soils was approved. An expanded bioventing system consisting of four additional vent wells (VW-2 through VW-5), three new MPs (MPD through MPF), a blower system, and associated piping, controls, and electrical service, was installed at Site FT-28. The existing vent well (VW-1) and existing monitoring well FT28-03 were also connected to the expanded bioventing system to serve as air injection vent wells. The three MPs (MPA through MPC) installed during previous pilot testing efforts and several groundwater monitoring wells were utilized to monitor system performance. System installation was performed by Parsons ES and Kelly Environmental Drilling, Inc. between January 19 and February 11, 1998. The system was installed as described in the *Interim Corrective Measures Work Plan for the Expanded Bioventing System, Eglin Main Base Old Fire Training Area* (Parsons ES, 1997). There were no significant deviations from the work plan, except that a 5-horsepower (HP) blower was installed instead of the 3-HP blower specified in the work plan (Parsons ES, 1998). The expanded bioventing system was started on February 11, 1998. Results of the soil gas sampling and respiration tests performed after one year of expanded-scale operation is summarized later in this report.

Interim Corrective Measure (ICM) for Surface Soil

In May 1998, an ICM for surface soil within the former burn pit at Site FT-28 was completed by BEM Systems of Fort Walton Beach, Florida. The ICM consisted of the following: 1) removal of the mock-up plane from the center of the former burn pit, 2) backfill of the former burn pit with clean, sandy fill, and 3) placement of grass sod over the backfilled area. Two vent wells (VW-1 and VW-4) and four monitoring points (MPA through MPD) were located in the backfilled area. To allow continued access to these points, new access vaults were installed.

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SUMMARY OF FEBRUARY 1999 FIELD EFFORT

Soil Gas Chemistry Results

Field screening and collection of soil gas samples for laboratory analysis were performed on 8 February 1999 following approximately 1 year of expanded-scale system oxygenation of site soils and 1 month of system shutdown. Soil gas samples were collected and field-screened to assess soil gas concentrations of oxygen, carbon dioxide, and total volatile hydrocarbons (TVH). Tables 1 and 2 summarize the field and laboratory soil gas results from sampling events performed before expanded-scale bioventing system commencement and after one year of operation.

Static oxygen concentrations at most of the monitoring locations were high (at concentrations ranging from 5 percent to the atmospheric concentration of 20.8 percent) both before and after expanded-scale bioventing treatment, indicating that concentrations of hydrocarbons were low and that any oxygen demand in these locations was being met naturally through diffusion from the atmosphere or nearby clean soils. At the four monitoring locations with low initial oxygen concentrations (MPC-S, MPC-I, MPF-D, and FT28-03), static oxygen concentrations in site soil gas generally did not increase following the first year of expanded-scale bioventing system operation. While oxygenation of the entire soil volume designated for bioventing treatment was demonstrated following installation and startup of the expanded-scale system in February 1998 (Parsons ES, 1998), subsurface conditions southeast of the burn pit and in the vicinity of FT28-03 continue to return to an anaerobic state following shut down of the blower system (Figure 1). The lack of oxygen in soil gas collected from MPC-S, MPC-I, MPF-D, and FT28-03 suggests that aerobic biodegradation of petroleum hydrocarbon contaminants by soil microbial populations is still occurring when oxygen is made available to the subsurface (i.e. provided through air injection bioventing). Elevated carbon dioxide concentrations in site soil gas further suggest that aerobic biodegradation is occurring in site soils and carbon dioxide is being produced as a by-product of the biodegradation. TVH concentrations in February 1999 decreased at MPB, MPC, MPD, MPE, MPF-S, FT28-03 and FT28-04 as compared to February 1998 measurements, but increased at MPA, MPF-I, and MPF-D.

Analytical soil gas results from the February 1999 and February 1998 sampling events are shown in Table 2. Benzene, toluene, ethylbenzene, and total xylenes (BTEX) and TVH concentrations generally decreased from 1998 to 1999 at MPC-I and MPD-S. However, concentrations increased at MPF-D. The screened interval at MPF-D was installed immediately above the groundwater table, and the concentration increases at MPF-D may be caused by a "smearing effect"; fluctuations in the elevation of the groundwater surface may have carried contaminants from the saturated zone into vadose zone soils in this location.

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RESPIRATION TEST RESULTS

As part of the field effort, *in situ* respiration testing was performed at the site between 8 and 11 February 1999 in accordance with protocol procedures (Hinchee, *et al.*, 1992). Prior to the test, air was injected for approximately 21 hours into three MPs (MPC-S, MPC-I, and MPF-D) and shallow monitoring well FT28-03 using 1-cubic foot per minute pumps to locally oxygenate soils in the vicinity of these points. Following air injection, changes in oxygen, carbon dioxide, and TVH soil gas concentrations were monitored over a 50-hour period. Observed rates of oxygen utilization were then used to estimate aerobic fuel biodegradation rates at the site. Biodegradation rates were calculated using a soil moisture content of 15.2 percent for shallow points and 18.4 percent for intermediate and deep points. These values were derived from soil samples collected at the site during previous investigations. Table 3 summarizes the respiration and fuel biodegradation rates determined during February 1999 field event and compares them to rates determined during pilot-scale bioventing. The graphs and tables used to calculate the biodegradation and oxygen utilization rates are presented in Attachment A.

As is evident from Table 3, *in situ* respiration and fuel biodegradation rates have decreased as a result of the first year of expanded-scale bioventing system operation. Observed oxygen utilization rates at the site have generally decreased since the beginning of pilot-scale bioventing system operation in July 1994. The greatest reduction in biodegradation and oxygen utilization rates occurred at MPC-S. Oxygen utilization and fuel biodegradation rates typically decrease with continued bioventing as the lighter, more readily biodegraded hydrocarbons (BTEX) are preferentially destroyed over more biologically recalcitrant, higher molecular weight hydrocarbons.

Although respiration testing results indicate that aerobic biodegradation rates are decreasing, biodegradation of petroleum hydrocarbons in unsaturated zone soils continues to be enhanced by the introduction of oxygen. This observation is further validated by the depleted static oxygen concentrations measured in site soil gas at several locations (MPC-S, MPC-I, MPF-D, and FT28-03). Finally, BTEX and TVH concentrations have increased at MPF-D (Table 2). These facts indicate that further biodegradation of the residual petroleum hydrocarbon contaminants in site soils could be achieved through continued bioventing system operation.

During system restart after the February 1999 field effort, flows to VW-1, VW-2, and FT28-03 were increased so that areas in the subsurface that were depleted of oxygen after the one-month shut down of the system (FT28-03, MPF and MPC) received more flow. Vent wells that supply oxygen to areas that were relatively oxygenated after the one-month system shutdown (VW-3, VW-4, and VW-5) received less flow.

RECOMMENDATIONS

Parsons ES recommends that the system be operated for an additional year at a minimum to continue to remediate hydrocarbons in site soil. At the end of the additional

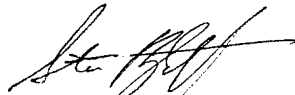
Major Ed Marchand
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year of operation, a round of soil gas sampling and respiration testing should be conducted to assess the progress of soil remediation at the site.

This report represents the final deliverable for Site FT-28 under the AFCEE Extended Bioventing Program. If you have any questions or comments regarding this site, please feel free to contact the project manager, Mr. John Ratz in our Denver office at (303) 831-8100, or myself at (678) 969-2361.

Sincerely,

PARSONS ENGINEERING SCIENCE, INC.



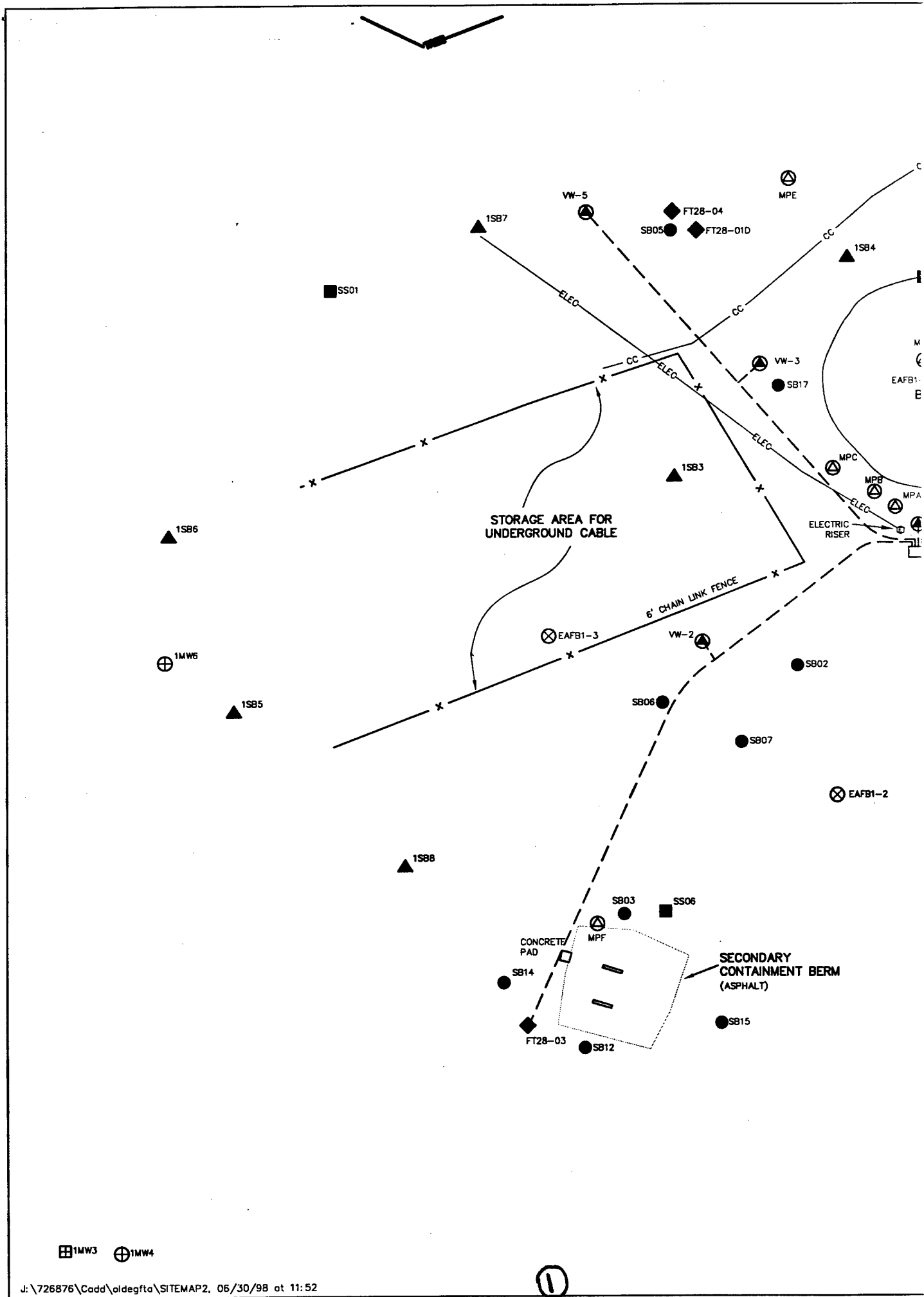
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Site Manager

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Attachments

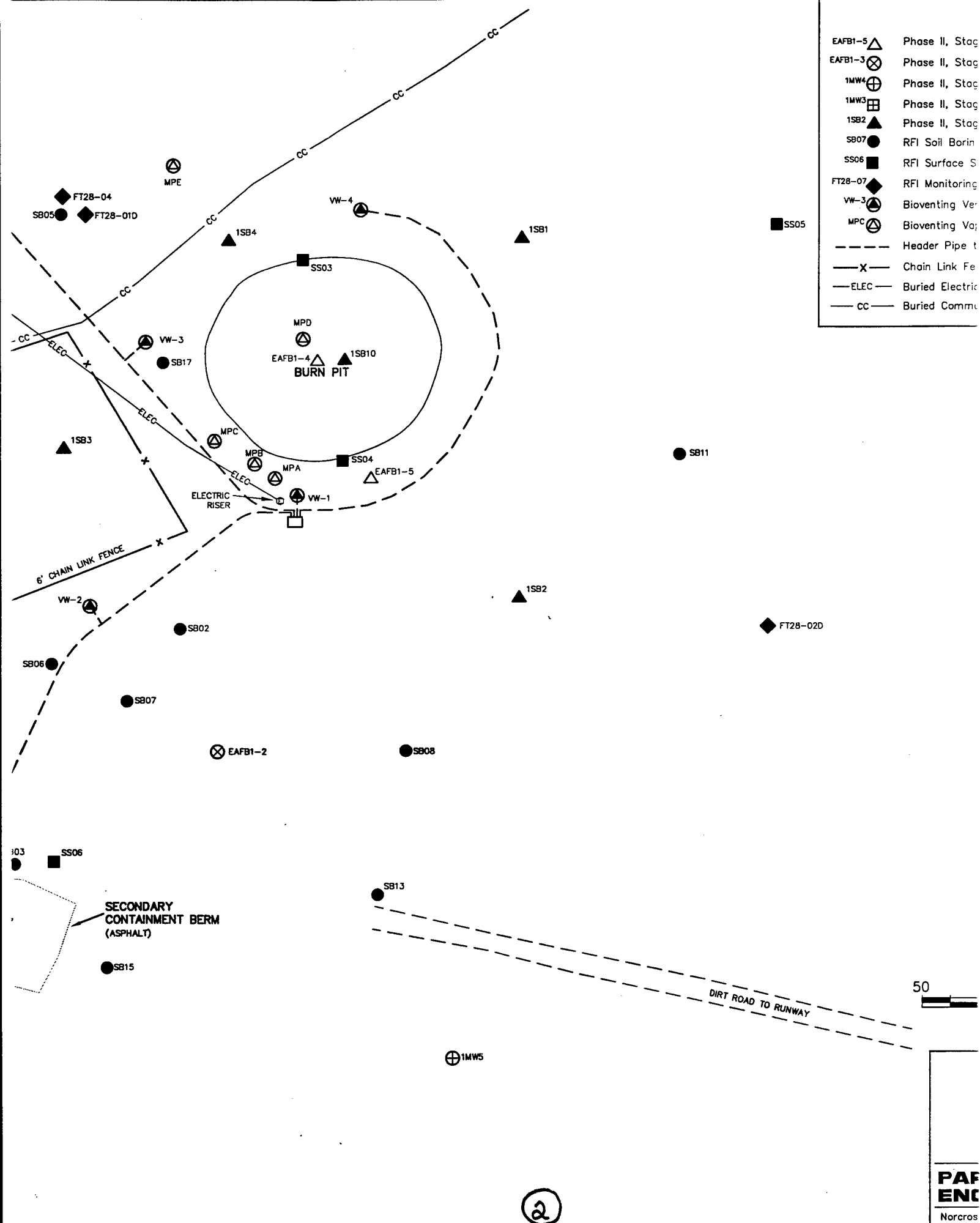
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- Parsons ES. 1997. Interim Corrective Measures Work Plan for the Expanded Bioventing System, Eglin Main Base Old Fire Training Area. December.
- Parsons ES. 1998. Letter Results Report to Major Marchand at AFCEE/ERT, Subject: Operation and Maintenance Manual, Record Drawings, and Summary of Initial Results for the Expanded Bioventing System Installed at Eglin Main Base Old Fire Training Area, Eglin Air Force Base, Florida. 30 June.



1MW3 1MW4

- | | | |
|---------|---|-----------------|
| EAFB1-5 | △ | Phase II, Stag |
| EAFB1-3 | ⊗ | Phase II, Stag |
| 1MW4 | ⊕ | Phase II, Stag |
| 1MW3 | ⊞ | Phase II, Stag |
| 1SB2 | ▲ | Phase II, Stag |
| SB07 | ● | RFI Soil Borin |
| SS06 | ■ | RFI Surface S |
| FT28-07 | ◆ | RFI Monitoring |
| VW-3 | ⊖ | Bioventing Ver |
| MPC | ⊙ | Bioventing Vq |
| --- | | Header Pipe t |
| -X- | | Chain Link Fe |
| -ELEC- | | Buried Electric |
| -CC- | | Buried Commu |



LEGEND

EAFB1-5	△	Phase II, Stage 2 Soil Boring Approximate Location (1986)
EAFB1-3	⊗	Phase II, Stage 2 Monitoring Well Approximate Location (1986)
1MW4	⊕	Phase II, Stage 3 Shallow Monitoring Well Approximate Location (1988)
1MW3	⊞	Phase II, Stage 3 Deep Monitoring Well Approximate Location (1988)
1SB2	▲	Phase II, Stage 3 Soil Boring Approximate Location (1988)
SB07	●	RFI Soil Boring (1995)
SS06	■	RFI Surface Soil Sampling Location (1995)
FT28-07	◆	RFI Monitoring Well Location (1995)
VW-3	⊖	Bioventing Vent Well
MPC	⊙	Bioventing Vapor Monitoring Point
---		Header Pipe to Vent Well
—X—		Chain Link Fence
—ELEC—		Buried Electrical Cable
—CC—		Buried Communications Cable

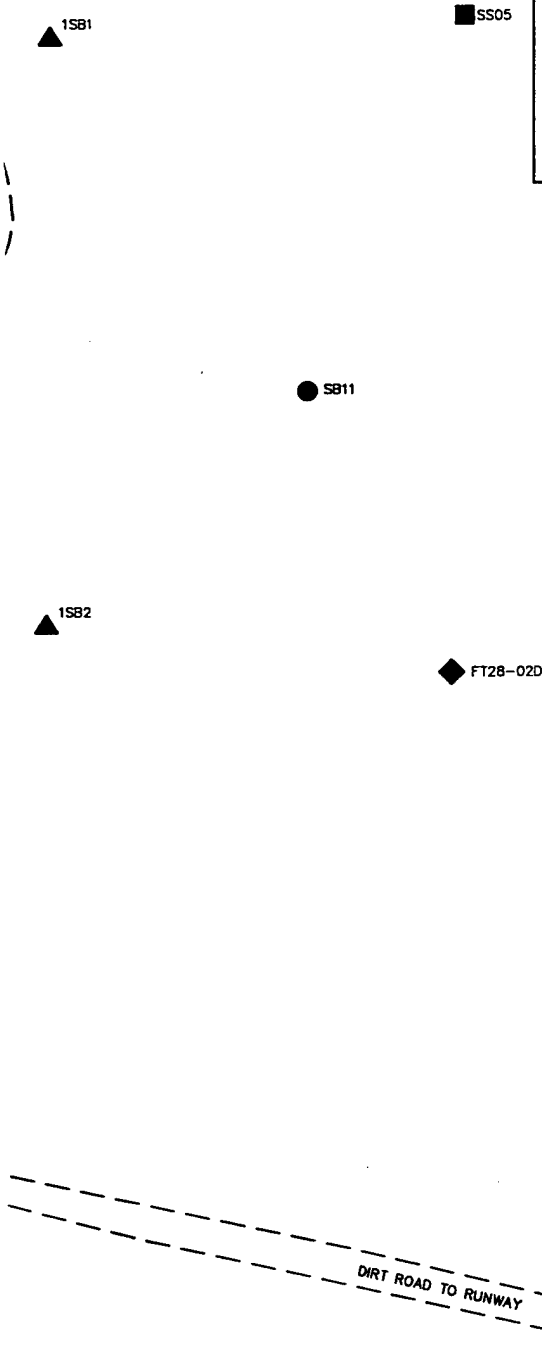


FIGURE 1

SITE MAP

EXPANDED BIOVENTING SYSTEM
EGLIN MAIN BASE OLD FTA
EGLIN AIR FORCE BASE

**PARSONS
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TABLE 1
FIELD SOIL GAS RESULTS
EGLIN MAIN BASE OLD FIRE TRAINING AREA (SITE FT-28)
EGLIN AIR FORCE BASE, FLORIDA

Sample Location	Screen Depth (feet)	Field Screening Data – January 23, 1998			Field Screening Data – February 8, 1999		
		Oxygen (%)	Carbon Dioxide (%)	TVH (ppmv) ^{a/}	Oxygen (%)	Carbon Dioxide (%)	TVH (ppmv)
MPA (S)	5	15.0	2.0	35	13.5	2.25	100
	(I) 26	16.0	2.1	33	14.0	3.5	88
	(D) 38	20.8	0.2	14	20.9	0.0	54
MPB (S)	5	12.0	2.9	140	10.5	4.5	70
	(I) 26	10.0	5.1	240	7.0	6.0	84
	(D) 38	20.8	0.25	120	20.5	0.0	72
MPC (S)	5	4.0	5.5	200	2.0	8.0	134
	(I) 26	0.0	10.2	400	0.0	14.5	132
	(D) 38	20.8	0.25	200	20.9	0.0	32
MPD (S)	5	15.0	2.0	1600	9.0	5.50	88
	(I) 20.5	16.0	0.8	1400	11.0	2.25	66
	(D) 36.5	16.5	1.0	500	20.9	0.0	52
MPE (S)	5	9.0	6.3	210	7.5	8.5	80
	(I) 20.5	14.0	3.8	190	14.0	2.5	62
	(D) 36.5	18.0	2.3	140	18.0	0.5	28
MPF (S)	5	14.5	4.0	98	19.0	1.5	46
	(I) 20.5	18.0	2.0	59	16.5	2.5	72
	(D) 36.5	0.0	12.0	400	0.0	14.0	920
VW-1	5-40	19	0.7	18	--- ^{b/}	---	---
VW-2	8-38	18.8	1.7	360	---	---	---
VW-3	8-38	17.9	2.0	200	---	---	---
VW-4	8-38	15.5	3.4	200	---	---	---
VW-5	5-35	14	4.8	240	---	---	---
FT28-03	37-47	0.5	12.5	2000	3.25	8.25	134
FT28-04	35-45	19.0	2.0	295	17.5	0.75	27
FT28-05	35-45	11.5	7.5	36	---	---	---
FT28-07	31-41	19.0	2.3	32	---	---	---
IMW-6	38-48	20.8	0.25	8	---	---	---

^{a/} TVH = total volatile hydrocarbon results reported in parts per million, volume per volume. Results include methane.

^{b/} ---- = not analyzed.

TABLE 2
LABORATORY SOIL GAS ANALYTICAL RESULTS
EGLIN MAIN BASE OLD FIRE TRAINING AREA (SITE FT-28)
EGLIN AIR FORCE BASE, FLORIDA

Sample Location	Screen Depth (feet)	Laboratory Analytical Data -- February 10, 1998					Laboratory Analytical Data -- February 8, 1999				
		Benzene (ppmv) ^{b/}	Toluene (ppmv)	Ethylbenzene (ppmv)	Xylenes (ppmv)	TVH ^{d/} (ppmv)	Benzene (ppmv)	Toluene (ppmv)	Ethylbenzene (ppmv)	Xylenes (ppmv)	TPH ^{a/} (ppmv)
MPC shallow intermediate ^{e/}	5	--- ^{c/}	---	---	---	---	0.0021 U ^{d/}	0.024	0.037	0.14	2.6 B ^{e/}
	26	0.019	0.098	0.064	0.55	63	0.0070 J ^{f/}	0.018	0.014	0.10	11 B
	26	0.015	0.069	0.039	0.37	53.6	0.013 J	0.038 J	0.012 J	0.11 J	11 B
MPD shallow ^{h/} intermediate ^{i/}	5	0.20 U	2.4	3.2	11	570	0.028	0.017	0.012	0.063	4.9 B
	20.5	0.020 U	0.021	0.058	0.29	23	---	---	---	---	---
	20.5	0.020 U	0.015 J	0.056	0.28	24	---	---	---	---	---
MPE shallow	5	0.004 U	0.011	0.027	0.058	14	---	---	---	---	---
MPF deep	36.5	0.15	2.2	3.9	12	430	4.3	13	15	60	1600 B

a/ TVH and TPH by Method TO-3 report the same range of hydrocarbons.

b/ results reported in parts per million, volume per volume.

c/ ---- = not analyzed.

d/ U = compound analyzed for, but not detected. The number shown represents the reporting limit.

e/ B = Compound present in laboratory blank, background subtraction not performed.

f/ J = Estimated value.

g/ 1998: Field duplicate of MPC intermediate depth (I). Sample ID on Chain of Custody: MPH-I. 1999: Laboratory duplicate of MPC intermediate depth.

Laboratory sample ID: MPC-Intermediate Duplicate.

h/ 1998: Analytical results for MPD shallow depth are from sample ID: MPG-Shallow (a field duplicate of MPD-Shallow). Summa canister for MPD-Shallow malfunctioned prior to analysis.

i/ 1998: Laboratory duplicate of MPD intermediate depth (I). Laboratory sample ID: MPD-I Duplicate.

TABLE 3
RESPIRATION AND DEGRADATION RATES
EGLIN MAIN BASE OLD FIRE TRAINING AREA (SITE FT-28)
EGLIN AIR FORCE BASE, FLORIDA

Location-Depth (feet below ground surface)	Pilot Scale Bioventing				Expanded-Scale Bioventing	
	Initial (March 1994)		3-Month (September 1994)		1-Year (February 1995)	
	K _o (% O ₂ /min)	Degradation Rate ^{a/} (mg/kg/year) ^{d/}	K _o (% O ₂ /min)	Degradation Rate ^{b/} (mg/kg/year)	K _o (% O ₂ /min)	Degradation Rate ^{c/} (mg/kg/year)
MPA (4.5 - 5')	0.0042	1,400	0.0018	620	NS ^{d/}	NC ^{d/}
MPA (25.5 - 26')	NS	NC	0.00011	28	NS	NC
MPA (38.5 - 39')	NS	NC	NS	NS	NS	NC
MPB (4.5 - 5')	NS	NC	0.0027	930	NS	NC
MPB (25.5 - 26')	0.0035	900	0.00051	130	NS	NC
MPC (4.5 - 5')	NS	NC	0.011	3,800	0.0024	420
MPC (25.5 - 26')	NS	NC	0.0015	380	0.0036	110
MPC (38.5 - 39')	0.0013	220	NS	NS	NS	NC
MPF (36.5-37')	NS	NC	NS	NC	0.0054	160
MW-FT28-03 (37'-water table)	NS	NC	NS	NC	0.0024	70

^{a/} Due to a delay in power installation, the extended test did not begin until July 6, 1994.

^{b/} Degradation calculation assumes moisture content of the soil is average of initial and final moistures.

^{c/} Assumes moisture content of 5 foot depths equal to the average soil moistures determined at VW-3-5 and MPB-2-4 for July 28, 1995 soil samples. Soil moisture at 26 foot depths assumed to be equal to moisture content at MPA-33-34 collected on October 20, 1995.

^{d/} Milligrams of hydrocarbons per kilogram of soil per year.

^{e/} NS = Not sampled.

^{f/} NC = Not calculated.

ATTACHMENT A

EGLIN AFB -- Eglin Main Old Fire Training Area (FT-28)

Biodegradation Rate Calculations

enter data

calculated data

Formula:

$$K_b = K_o \times 1/100\% \times A \times D_o \times C \quad \text{Where:}$$

K_b = fuel biodegradation rate

K_o = O_2 utilization rate (%/min.)

A = volume of air/kg soil

D_o = O_2 density = 1340 mg/L

C = Carbon/ O_2 ratio for hexane mineralization = 1/3.5

Solving for 1 L of soil:

February 1999

Monitoring Point:

Oxygen util. rate

Moisture content ^{a/}

Soil Type ^{b/}

K_o =

%/min.

w =

%

MPC-S	MPC-I	MPF-D	FT28-03
0.00236	0.00357	0.00538	0.00238
15.2	18.4	18.4	18.4

SAND, loose	SAND	SAND	SAND
-------------	------	------	------

Porosity:

Unit weight (dry):

Void ratio:

Specific gravity:

n =

$g_d = G \cdot g_w \cdot (1-n)$ =

$e = n / (1-n)$ =

G =

g/cm³

2.65

0.40	0.35	0.35	0.35
1.59	1.72	1.72	1.72
0.67	0.54	0.54	0.54
2.65	2.65	2.65	2.65

Void volume:

Deg. of saturation:

Volume of water:

Volume of air:

$V_v = n \cdot 1 \text{ L}$ =

$S_r = G_w / e$ =

$V_w = S_r \cdot V_v$ =

$V_a = V_v - V_w$ =

liters

liters

liters

0.4	0.35	0.35	0.35
0.6	0.9	0.9	0.9
0.24	0.32	0.32	0.32
0.16	0.03	0.03	0.03

Bulk density:

Air filled volume:

$g_d + (V_w \cdot g_w)$ =

$A = V_a / \text{Bulk Density}$

kg/L soil

L air/kg soil

1.8	2	2	2
0.089	0.015	0.015	0.015

$$K_b = K_o \cdot 1/100\% \cdot A \cdot D_o \cdot C \cdot 525,600 \text{ min/yr}$$

K_b =

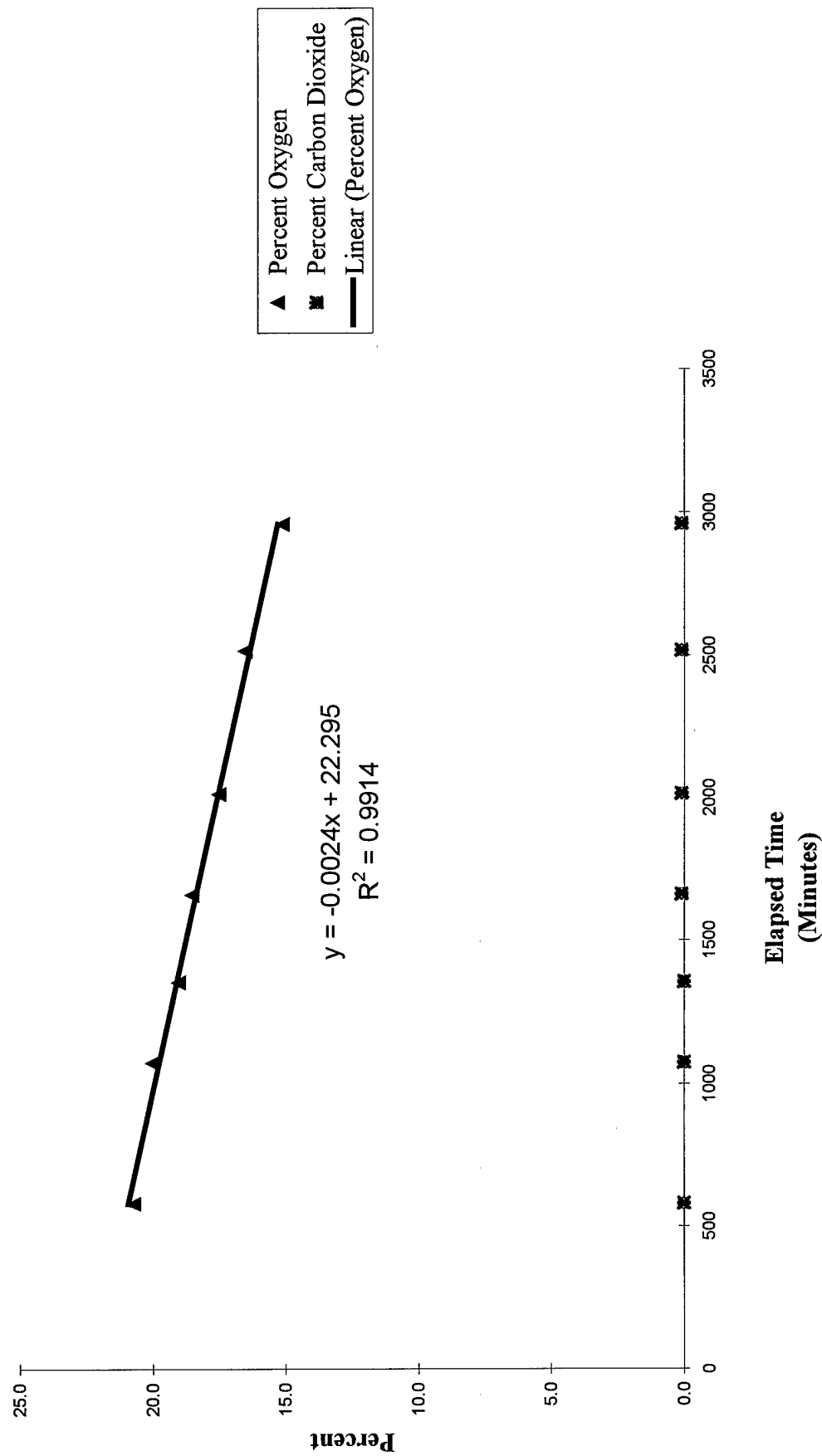
mg TPH/
kg soil/
year

423	108	162	72
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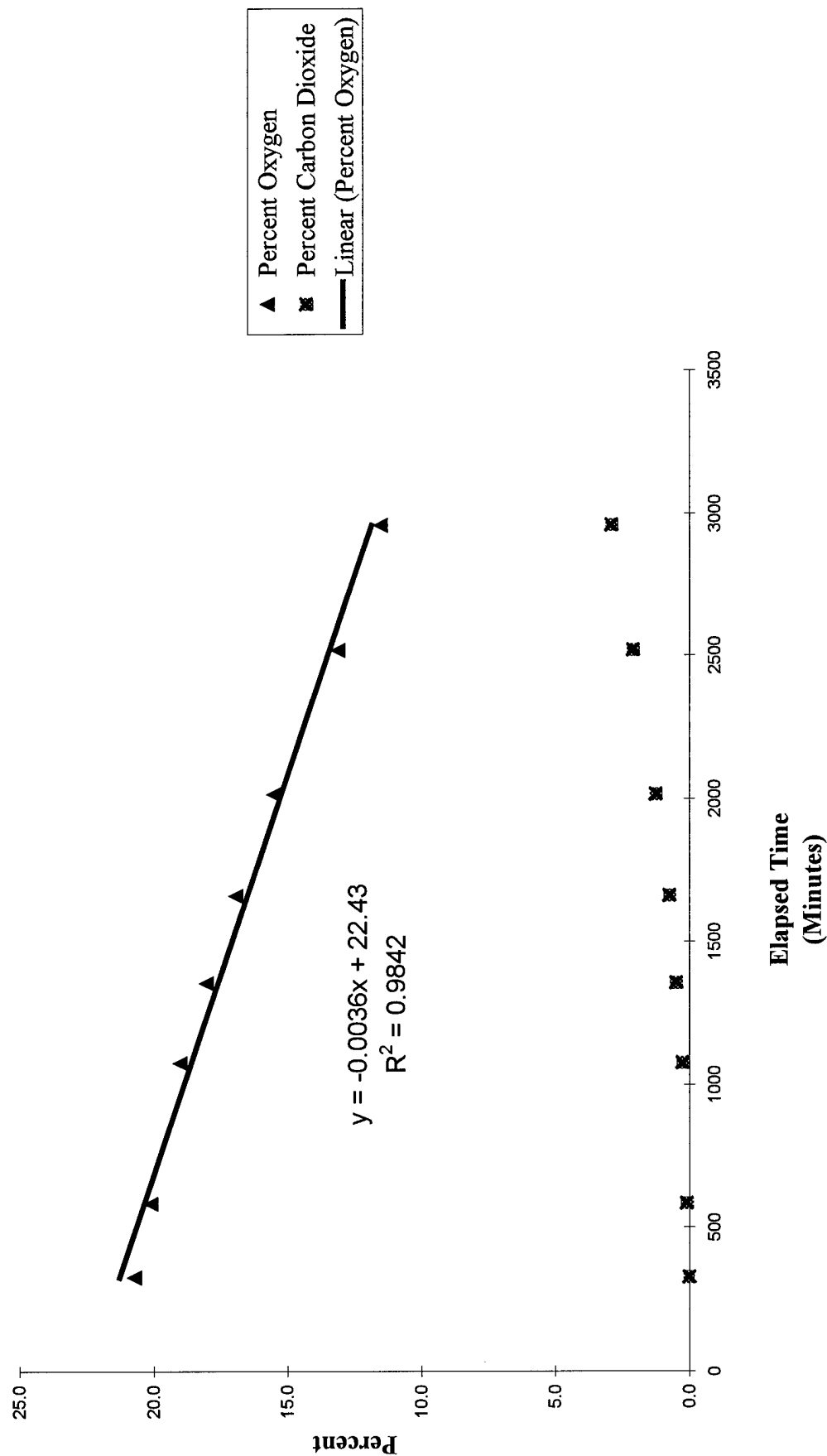
^{a/} Assumes moisture content of 5 foot depths equal to the average soil moistures determined at VW-3-5 and MPB-2-4 for July 28, 1995 soil samples. Soil moisture at 26 foot depths assumed to be equal to moisture content at MPA-33-34 collected on October 20, 1995.

^{b/} Assume: Soil properties are specified from Table 1.4. (Ref. Foundation Engineering, Peck, Hanson, and Thornburn, John Wiley Press, 1974)

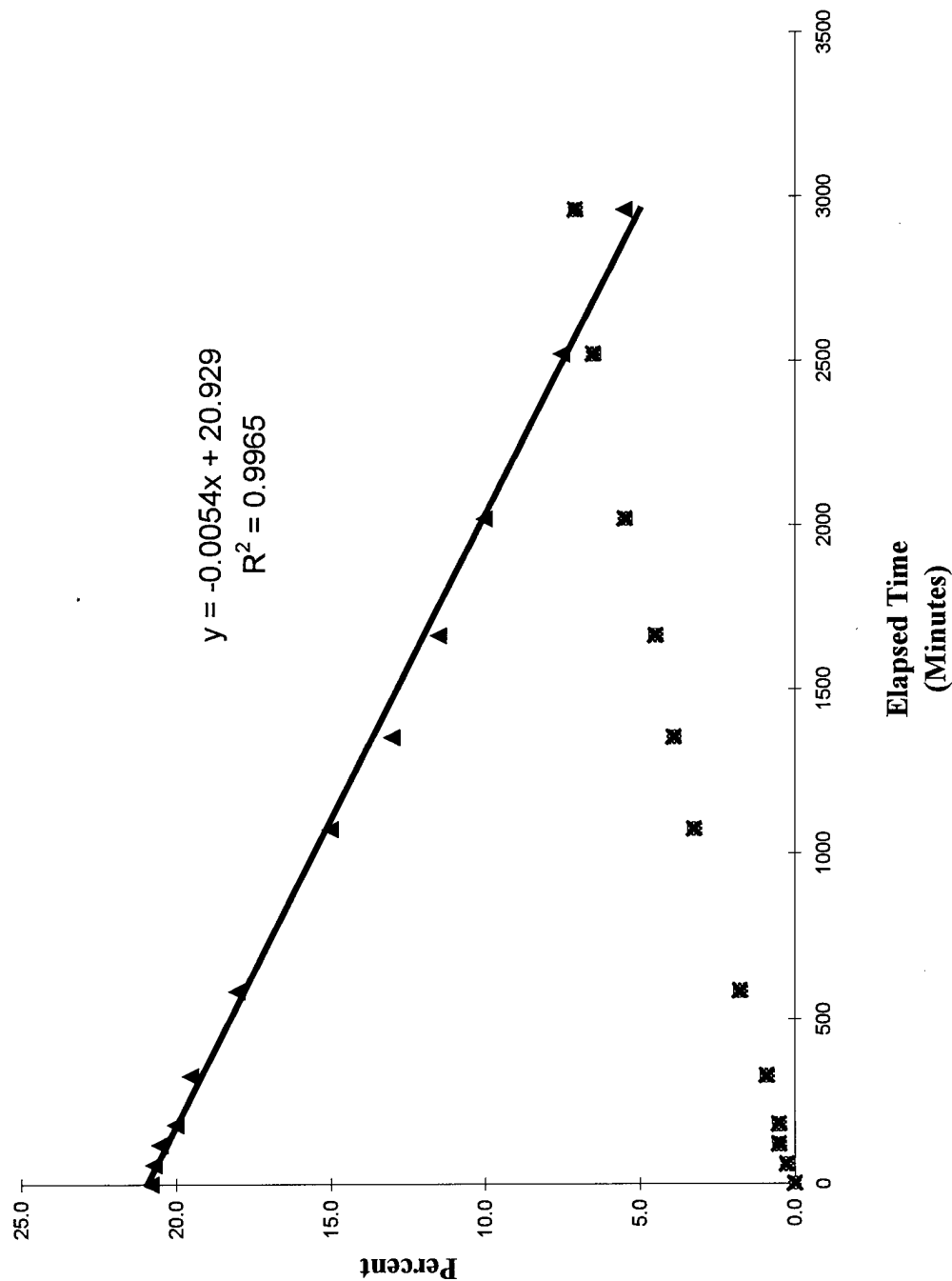
Percent Oxygen and Percent Carbon Dioxide at MP-C Shallow During the February 1999 Respiration Test at FT-28 Old Eglin Main Fire Training Area Eglin AFB, Florida



Percent Oxygen and Percent Carbon Dioxide at MP-C Intermediate During the February 1999 Respiration Test at FT-28 Old Egin Main Fire Training Area Egin AFB, Florida



Percent Oxygen and Percent Carbon Dioxide at MP-F Deep During the February 1999 Respiration Test at FT-28 Old Eglin Main Fire Training Area Eglin AFB, Florida



**Percent Oxygen and Percent Carbon Dioxide at FT28-03 During the February 1999
Respiration Test at FT-28
Old Eglin Main Fire Training Area
Eglin AFB, Florida**

